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# THE UNITED STATES OF AMERICA

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*March 16, 2005*

**THIS IS TO CERTIFY THAT ANNEXED HERETO IS A TRUE COPY FROM THE RECORDS OF THE UNITED STATES PATENT AND TRADEMARK OFFICE OF THOSE PAPERS OF THE BELOW IDENTIFIED PATENT APPLICATION THAT MET THE REQUIREMENTS TO BE GRANTED A FILING DATE.**

**APPLICATION NUMBER: 60/550,240**

**FILING DATE: *March 03, 2004***

**RELATED PCT APPLICATION NUMBER: *PCT/US05/06380***



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Patent and Trademark Office



Express Mail No: EV381773142US  
Attorney Docket: DakoCytoFech



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UNITED STATES PATENT AND  
TRADEMARK OFFICE

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In Re the Provisional Application of: Theodore W. Jochum, Daniel N. Fox, Thomas L. Thrasher,  
George C. Malachowski

Serial Number:

Filed:

For: System for High Dynamic Range Analysis in Flow Cytometry

Assignee: DakoCytomation Denmark A/S

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**LETTER OF TRANSMITTAL**

Mail Stop Provisional Patent Application  
Commissioner for Patents  
P.O. Box 1450  
Alexandria, VA 22313-1450

Dear Sir:

Enclosed for filing are:

1. a Provisional Application Cover Sheet (1 page);
2. an Application Data Sheet (4 pages);
3. a Specification (16 pages) and Drawings ( 4 pages);
4. a List of References Incorporated by Reference in Accordance with the Provisional Application (2 pages) and copies of those references;
5. this Letter of Transmittal (2 pages) along with a Credit Card Payment Form authorization (1 page) in the amount of \$160.00 for the provisional filing fee;
6. Certificates of Express Mailing for each document and a return postcard.

Please confirm receipt of the documents by applying your date stamp on the enclosed postcard receipt and returning it to me.

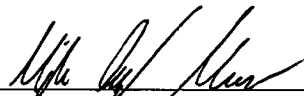
**Please address all future correspondence to: Santangelo Law Offices, P.C., 125 South Howes, Third Floor, Fort Collins, CO 80521.**

I have this 3 day of March 2004, either myself personally or through my direction of staff at this office, deposited all of the items in the above letter of transmittal with the United States Postal Service as Express Mail, postage prepaid, in an envelope addressed to: Mail Stop Provisional Application, Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.

Dated this 3 day of March, 2004.

Respectfully Submitted,  
SANTANGELO Law Offices, P.C.

By:

  
\_\_\_\_\_  
Misha Gregory Macaw  
ATTORNEY FOR APPLICANT  
PTO No. 55,417  
125 South Howes, Third Floor  
Fort Collins, Colorado 80521  
(970) 224-3100

dakocytomation/fechner/provis-xmt

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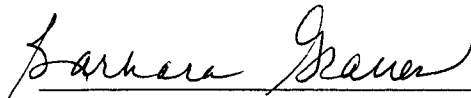
**CERTIFICATE OF EXPRESS MAILING**

I, Barbara Graves, hereby certify to the truth of the following items:

1. I am an employee of Santangelo Law Offices, P.C., 125 South Howes, Third Floor, Fort Collins, Colorado 80521.

2. I have this day deposited the attached Letter of Transmittal (2 pages) along with a Credit Card Payment Form authorization (1 page) in the amount of \$160.00 for the Provisional Filing Fee with the United States Postal Service as "Express Mail" for mailing to Mail Stop Provisional Patent Application, Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.

Dated this 31<sup>st</sup> day of March, 2004.

  
\_\_\_\_\_  
Barbara Graves

Express Mail No: EV381773142US  
Attorney Docket: DakoCytoFech

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1. I am an employee of Santangelo Law Offices, P.C., 125 South Howes, Third Floor, Fort Collins, Colorado 80521.

2. I have this day deposited the attached Application Data Sheet (4 pages) with the United States Postal Service as "Express Mail" for mailing to Mail Stop Provisional Patent Application, Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.

Dated this 3rd day of March, 2004.

  
Barbara Graves

**PROVISIONAL APPLICATION COVER SHEET**

EFS Customer No. 33549			Docket Number: DakoCytoFech		
INVENTOR(s)/APPLICANT(s)					
Last Name	First Name	Middle Initial	RESIDENCE (CITY AND EITHER STATE OR FOREIGN COUNTRY)		
Jochum	Theodore	W.	720 Yarnell Court, Fort Collins, CO 80525, US		
Fox	Daniel	N.	2726 Bradford Square, Fort Collins, CO 80526, US		
Thrasher	Thomas	L.	2318 Kodiak Road, Fort Collins, CO 80525, US		
Malachowski	George	C.	1112 Remington Street, Fort Collins, CO 80524, US		
TITLE OF THE INVENTION (280 characters max.)					
System for High Dynamic Range Analysis in Flow Cytometry					
CORRESPONDENCE ADDRESS					
Misha Gregory Macaw SANTANGELO LAW OFFICES, P.C. 125 South Howes, Third Floor Fort Collins, CO 80521					
STATE	CO	ZIP CODE	80521	COUNTRY	USA
ENCLOSED APPLICATION PARTS (Check all that apply)					
<input checked="" type="checkbox"/>	Application Data Sheet			Number of Pages: 4	
<input checked="" type="checkbox"/>	Provisional Cover Sheet			Number of Pages: 1	
<input checked="" type="checkbox"/>	Specification			Number of Pages: 16	
<input checked="" type="checkbox"/>	Drawing(s)			Number of Sheets: 4	
	Photographs			Number of Photos	
	Small Entity Status			Number of Pages	
	Power of Attorney			Number of Pages:	
<input checked="" type="checkbox"/>	a list of references to be incorporated by reference and copies of those references			Number of Pages: 2	
	Assignment of Patent Rights and recordation cover sheet			Number of Pages:	
<input checked="" type="checkbox"/>	Certificates of Express Mail for each document				
<input checked="" type="checkbox"/>	Letter of Transmittal			Number of Pages: 2	
METHOD OF PAYMENT (check one)					
<input type="checkbox"/> A check or money order is enclosed to cover the Provisional filing fees			PROVISIONAL FILING FEE		
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<input type="checkbox"/> The Commissioner is hereby authorized to charge filing fees and credit Deposit Account Number: _____					

The invention was made by an agency of the United States Government or under a contract with an agency of the United States Government.

☒ No

☐ Yes, the name of the U.S. Government agency and the Government contract number are: \_\_\_\_\_

Respectfully submitted,

SIGNATURE

Misha Gregory Macaw, PTO Registration No.: 55,417

DATE: March 3 2004.

**PROVISIONAL APPLICATION FILING ONLY**

Express Mail No: EV381773142US  
Attorney Docket: DakoCytoFech

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1. I am an employee of Santangelo Law Offices, P.C., 125 South Howes, Third Floor, Fort Collins, Colorado 80521.

2. I have this day deposited the attached Specification for "System for High Dynamic Range Analysis in Flow Cytometry" consisting of (16) pages and (4) sheets of Drawings with the United States Postal Service as "Express Mail" for mailing to Mail Stop Provisional Patent Application, Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.

Dated this 3<sup>rd</sup> day of March, 2004.

  
Barbara Graves

## SYSTEM FOR HIGH DYNAMIC RANGE ANALYSIS IN FLOW CYTOMETRY

### 5 BACKGROUND OF THE INVENTION

This invention relates to a method and apparatus for the analysis, and possible sorting, of particles, e.g., in a flow cytometer. Flow cytometers typically analyze particles by applying a stain or reagent, suspending them within a stream of sheath fluid, and passing the stream linearly through a laser. When the laser strikes the particles, it produces several channels of information in the form of scattered light and emitted light at different wavelengths. Traditionally, photo diodes and/or photo multiplier tubes are then used to convert the optical signal into an electronic signal, which may then be measured and characterized. However, depending on particle size, the particular chemicals used, laser power, and many other factors, the signals produced may occupy a large range of magnitudes. A small, unstained particle or “negative” particle may produce a signal with magnitude of only  $1/10000^{\text{th}}$  or less than that of a large, stained particle. Furthermore, some systems require analyzing particles at rates of over 50,000 per second, but also possibly as slow as only several per second. Accurate analysis over this large range of magnitudes and event rates has introduced many problems.

Early systems designed to analyze these signals used an analog approach for peak determination of the linear, logarithmic, and integral values during a gated window, and then digitized the peak values at the end of the window. These systems sometimes took an input signal, used a standard base line restoration (BLR) circuit to remove DC offsets, then used a linear amplifier to create the linear value, a logarithmic amplifier to create the logarithmic value, and an integrator circuit to calculate the integral during the window. An analog peak sample and hold circuit (PSH) was sometimes used to find the maximum value during the event, and this maximum value was sometimes then converted with an analog to digital converter (ADC) to get a digital value. The logarithmic amplifier was sometimes used to allow a wider dynamic range of analysis than the linear signal could provide.

These types of systems give a good starting point for signal analysis, but have some inherent problems. Some of these problems include:

- 5           1.       Analog logarithmic amplifiers usually do not have a perfect transfer function, and contain can “ripples” that may distort the input signal. Thus, the output can be higher or lower than it should have been depending upon the input magnitude, which introduced errors into calculations and distorted population histograms.
- 10          2.       Analog PSH circuits can have several problems, such as noise susceptibility, that may add to the inherent error of the system.
3.       In some cases, especially at very high event rates, the standard BLR circuit may introduce errors of its own. This error, which may manifest itself as a DC bias, may cause pulse distortion as the logarithmic amplifier input crosses from positive to negative and back to positive.

15

Perhaps to eliminate some of these problems, a second system was developed that eliminated the logarithmic amplifier and analog PSH circuit. In some arrangements this system took the input signal, used a standard BLR to remove DC offsets, applied different levels of linear gain, sampled the signals with ADCs, and then used a processor  
20 to select data from the optimal range and to perform a digital PSH. The multiple linear gain stages were sometimes necessary to provide adequate dynamic range.

This system may sometimes have removed the non-linearity problem of the logarithmic amplifier by not using one, and also may sometimes have removed the  
25 problems of the analog PSH circuit. However, these systems did not always eliminate all of the problems, and sometimes introduced some of their own. Some of the problems with this system include:

- 30           1.       In some cases, especially at very high event rates, the standard BLR circuit may introduce errors of its own. This error, which may manifest

itself as a DC bias, may cause pulse distortion as the varying stages of gain amplify the offset by different amounts.

2. Transitions from one gain stage to another may not be necessarily perfect, and may create “elbow” effects of non-linear regions.
- 5 3. Multiple gain stages per channel may require considerable hardware, and the processing power needed to analyze multiple signals per channel again may require considerable hardware.

Perhaps in an attempt to eliminate some of the original problems in a similar  
10 manner, a third system was created. In some arrangements, this system may have taken the input signal, perhaps used a standard BLR to remove DC offsets, maybe used ADCs to directly sample the signal, then sometime may have used a processor to perform digital PSH functionality. A high resolution ADC was sometimes used to achieve the desired dynamic range. A permutation of this system could sometimes omit the standard BLR,  
15 because there are no high gain stages that would be saturated by the offset.

This system may have removed the non-linearity problem of the logarithmic amplifier, the problems of the analog PSH, and the problems of using multiple gain stages. However, this type of system also may have introduced some problems. The  
20 problems with this type of system include:

1. Analysis dynamic range is sometimes limited to ADC resolution perhaps because the signal is directly sampled. With this system, very high resolution sometimes is required to detect and characterize signals  
25 of low magnitude. For example, using a normalized maximum input of 10V to the ADC, to get a fairly standard 12 bits of resolution over 4 decades (80 dB), the ADC may need to have at least 1024 steps in the last decade. In situations where the last decade is a maximum of 10mV, each step may need to be 10uV, which may require an ADC  
30 with at least 20 bits. Using an ADC with lower resolution could result in quantized, or “picket fence,” results. To achieve 5 decades (100dB),

the ADC may need at least 24 bits, and 6 decades (120dB) may require 27 bits. This may mean that system dynamic range may be limited by ADC technology. To achieve the necessary high resolution, sample speed may need to be given up, which may limit the speed that the signal may be sampled at, which may further limit the speed of overall analysis. A trade-off between analysis rates and resolution then may need to be made, which may make the lower end of the dynamic range quantized.

Prior work for particle analysis electronics in flow cytometry has apparently failed to solve these challenges without introducing new problems. Consequently, there is still a need for analysis electronics that can provide high dynamic range analysis at high event rates.

## **SUMMARY OF THE INVENTION**

The present invention provides a novel method of accurately and precisely measuring or characterizing properties of the input signal, especially for a flow cytometer. Signal parameters may be measured or calculated without many of the limitations or errors previously imposed, perhaps providing more accurate data. The invention may alleviate or avoid issues such as, but not limited to, standard BLR error, analog PSH errors, converter or system non-linearities, multi-region “elbow” effects, high sample rate requirements, and high resolution requirements.

These ill effects may be avoided or alleviated with all or portions of the present invention. The invention may prevent standard BLR errors, if needed, by not allowing the BLR to adjust during periods of sample acquisition. The base line may be removed before acquisition or between events and held constant during pulses. If necessary, during high event rates the base line may be held constant to prevent error from slowly accumulating. If no error is allowed to enter into the system from the BLR circuit, the eventual results may be more accurate and precise.

In some embodiments the present invention may remove converter or system non-linearities, if needed, by determining the errors and then compensating for them. For example, an analog logarithmic amplifier may be used as a signal converter, but it may  
5 contain non-linearities. However, in some embodiments the invention can provide a means of determining the errors in the transfer function, and a means of applying a correction scheme to reduce or eliminate the error. By removing the non-linearities of the system, result accuracy and precision may again be improved.

10 In other embodiments, the present invention may separate the required digitization resolution from the sampled dynamic range. This may provide a tremendous benefit by allowing an analysis of a much larger dynamic range, and by allowing for flexibility in analyzing different dynamic ranges. Embodiments may accomplish this by applying a non-linear transfer function to the input signal, which may effectively  
15 compress a very large dynamic range into a much smaller one by applying greater gains at lower magnitudes. The non-linear transfer function may even be matched to the desired dynamic range and desired response, producing a new signal that may be analyzed at a lower resolution while still providing adequate resolution for the low end of the dynamic range.

20 In addition, embodiments may decrease the sample rate needed to achieve accurate measurement or characterization via the same non-linear transfer function. If higher gains are applied to smaller magnitudes, and smaller gains to higher magnitudes, as with a non-linear transfer function, large signal swings may be reduced, effectively  
25 reducing the signal bandwidth. Embodiments may then find the peak, if necessary, by sampling the output of the transformation at a slower rate than would be needed if the input signal were sampled.

Therefore, by, in part or in combination, eliminating standard BLR errors,  
30 removing system or converter non-linearities, separating digitization resolution from dynamic range, or reducing signal bandwidth, embodiments of the present invention may

provide more accurate and precise results for high dynamic ranges and high event rates than previously possible, especially as applied to a flow cytometer.

## **BRIEF DESCRIPTION OF THE DRAWINGS**

5

**FIG. 1** – Early System for Signal Analysis – Shows a block diagram of a design of an earlier signal analysis system for flow cytometry.

**FIG. 2** – Logarithmic Amplifier Non-Linearities – Shows an example of non-linearities  
10 that may exist in a logarithmic amplifier.

**FIG. 3** – Second System for Signal Analysis – Shows a block diagram of a second system for signal analysis for flow cytometry.

15 **FIG. 4** – Third System for Signal Analysis – Shows a block diagram of a third system for signal analysis for flow cytometry.

**FIG. 5** – Compensated Logarithmic Amplifier – Shows an example of a logarithmic  
20 amplifier transfer function after compensating for non-linearity errors.

**FIG. 6** – Example of Non-Linear Transfer Function – Shows an example of a non-linear transfer function, in this case, a logarithmic amplifier.

**FIG. 7** – Effect of Non-Linear Transfer Function on Sampling Rate – Shows an effect of  
25 a logarithmic transfer function on a sample rate to characterize or measure the pulse perhaps without introducing errors.

**FIG. 8** – One Embodiment of the Invention – Shows one embodiment of a new system  
30 for signal analysis in flow cytometry.

## **DESCRIPTION OF THE PREFERRED EMBODIMENTS**

The present invention includes a variety of aspects, which may be combined in different ways. The following descriptions are provided to list elements and describe some of the embodiments of the present invention. These elements are listed with initial  
5      embodiments, however it should be understood that they may be combined in any manner and in any number to create additional embodiments. The variously described examples and preferred embodiments should not be construed to limit the present invention to only the explicitly described systems, techniques, and applications. Further, this description should further be understood to support and encompass descriptions and claims of all the  
10     various embodiments, systems, techniques, methods, devices, and applications with any number of the disclosed elements, with each element alone, and also with any and all various permutations and combinations of all elements in this or any subsequent application.

15           As mentioned, some early systems designed to analyze the signals of a flow cytometer used an analog approach for peak determination of the linear, logarithmic, and integral values during a gated window, and then digitized the peak values at the end of the window. Referring to Fig. 1, this type of a system sometimes took an input signal (1), used a standard base line restoration (BLR) (2) circuit to remove DC offsets, then used a  
20     linear amplifier (3) to create the linear value, a logarithmic amplifier (4) to create the logarithmic value, and an integrator circuit (5) to calculate the integral during the window. An analog peak sample and hold circuit (PSH) (6) may then have been used to find the maximum value during the event, and this maximum value may then have been converted with an analog to digital converger (ADC) (7) to get a digital value. Fig. 2  
25     shows an example of some non-linearities that may have existed in a logarithmic amplifier.

A second type of system for signal analysis is shown in Fig. 3. This system takes the input signal (1), uses a standard BLR (2) to remove DC offsets, applies different  
30     levels of linear gain (8), samples the signals with ADCs (7), and then uses a processor (9) to select data from the optimal range and to perform a digital PSH.



A third type of system for signal analysis is shown in Fig. 4. This system takes the input signal (1), uses a standard BLR (2) to remove DC offsets, uses ADCs (7) to directly sample the signal, then uses a processor (9) to perform digital PSH functionality.

5

Now turning to the present invention, one embodiment of the present invention may be seen in detail in Fig. 8. Here, an input signal (1) may have any DC offset removed by an enhanced BLR (15) that may be locked during acquisition. The signal may then be transformed by a logarithmic amplifier (4), perhaps calibrated with gain and offset adjustments (16), sampled by an ADC (7), and fed to a processor (9). The processor (9) may accept one or more channels of data, with one or more processors (9) per board, and one or more boards per system. This may allow for a flexibility of overall number of channels. The processor (9) may be used to perform the digital PSH function, as well as calculate or generate any other parameters desired, or provide other needed functionality.

15

One embodiment of the present invention to perform the enhanced BLR (15) with locking may be to analyze the output of the ADC (7) by the processor (9), while adjusting a DC level that is summed into the input signal by the enhanced BLR (15). A digital to analog converter (DAC) may be used to implement the DC voltage. When the ADC (7) output is at the correct level, the DC offset may remain fixed. In many cases, the output of the logarithmic amplifier may be the absolute deviation from zero volts, so the correct level could be the minimum output of the logarithmic amplifier. By fixing the offset during acquisition, the base line may not be in jeopardy of being affected by sample rate and creating error.

20

An embodiment of the present invention that may be used to correct for system or converter non-linearities may be to use a logarithmic amplifier (4), and then perform a calibration that measures the errors over the range of the inputs. Given a known input, the deviation from the theoretical transfer function value may be calculated. The processor (9) may then compensate the measured data to correct for the errors, perhaps

30

producing an effective transfer function with little or no error, as shown in Fig. 5. A further embodiment of the invention may be to use a look up table to change every ADC value to the corrected value. The correction table may be calculated for every channel to compensate for differences between components, channels, and boards.

5

An embodiment of the present invention that may separate digitization resolution from sampled dynamic range may use the non-linear transfer function of the logarithmic amplifier (4) to compress the dynamic range of the input signal (1). The logarithmic transfer function may convert a linear signal to an output that may be linear in dB to the input signal (1). Thus, for every decade of change in the input, the output may change a fixed amount. For example, Fig. 6 shows a logarithmic transfer function where the output changes 1V for every 20dB of input change. This output then may be measured or characterized at much lower resolution than would be needed for the original input signal. For example, if 12 bits were needed, a 12-bit ADC could be used. This shows a clear improvement over the 20 bits previously needed to analyze the input signal with the same resolution. By separating the required digitization resolution from the sampled dynamic range, the invention may provide greater flexibility and unbounded range for current and future analysis components. In one embodiment, a 14-bit ADC may be used to achieve high resolution sampling evenly spread over each decade of input. However, alternate configurations may be able to use much lower resolution ADCs, such as 8-bit converters.

An embodiment of the present invention that can reduce signal bandwidth by a non-linear transfer function may be to use a logarithmic amplifier (4) to convert the input signal (1). By compressing the dynamic range, a lower sample rate may be used without introducing error or noise, because the signal now has a lower bandwidth. An example of this is shown in Fig. 7, where the input signal (10) is transformed through a non-linear transfer function, in this case a logarithmic conversion, to produce an output signal (11). The maximum error allowed for the conversion (12) is used to indicate the sample rate needed, at worst case, to sample at least once within or at the maximum error limit. The sample period for the linear signal (13) may be considerably smaller than for the transformed signal (14). By increasing the period, the sample rate needed may decrease.

This effect may be used to reduce the sample rate and/or decrease the pulse width needed for accurate analysis. In one embodiment, for a Gaussian pulse width of approximately four micro-seconds at the six-sigma level, the essential bandwidth of the input signal may be approximately 330kHz. However, after the logarithmic conversion, the essential  
5 bandwidth may be reduced to approximately 55kHz. This dramatic drop in signal bandwidth may allow for a slower sample rate to fully characterize or measure the signal. Other embodiments of the invention could take advantage of this method by sampling at even slower rates and up-sampling and filtering in hardware or software to reconstruct the signal.

10

Another embodiment of the present invention may use all of these individual embodiments to create a system that may have less BLR error, less conversion non-linearity error, more flexible and perhaps unbounded dynamic range, and a reduced sampling rate for pulse analysis. These embodiments individually or in collusion may  
15 create analysis electronics for flow cytometry with improved accuracy and precision for high dynamic ranges without requiring undue costs or hardware.

As can be easily understood from the foregoing, the basic concepts of the present invention may be embodied in a variety of ways. It involves both signal measurement  
20 and signal analysis techniques as well as devices to accomplish the appropriate signal measurements and signal analysis. In this application, the signal measurement and signal analysis techniques are disclosed as part of the results shown to be achieved by the various devices described and as steps which are inherent to utilization. They are simply the natural result of utilizing the devices as intended and described. In addition, while  
25 some devices are disclosed, it should be understood that these not only accomplish certain methods but also can be varied in a number of ways. Importantly, as to all of the foregoing, all of these facets should be understood to be encompassed by this disclosure.

The discussion included in this provisional application is intended to serve as a  
30 basic description. The reader should be aware that the specific discussion may not explicitly describe all embodiments possible; many alternatives are implicit. It also may

not fully explain the generic nature of the invention and may not explicitly show how each feature or element can actually be representative of a broader function or of a great variety of alternative or equivalent elements. Again, these are implicitly included in this disclosure. Where the invention is described in device-oriented terminology, each  
5 element of the device implicitly performs a function. Apparatus claims may not only be included for the device described, but also method or process claims may be included to address the functions the invention and each element performs. Neither the description nor the terminology is intended to limit the scope of the claims that will be included in any subsequent patent application.

10

It should also be understood that a variety of changes may be made without departing from the essence of the invention. Such changes are also implicitly included in the description. They still fall within the scope of this invention. A broad disclosure encompassing both the explicit embodiment(s) shown, the great variety of implicit  
15 alternative embodiments, and the broad methods or processes and the like are encompassed by this disclosure and may be relied upon when drafting the claims for any subsequent patent application. It should be understood that such language changes and broader or more detailed claiming may be accomplished at a later date (such as by any required deadline) or in the event the applicant subsequently seeks a patent filing based  
20 on this filing. With this understanding, the reader should be aware that this disclosure is to be understood to support any subsequently filed patent application that may seek examination of as broad a base of claims as deemed within the applicant's right and may be designed to yield a patent covering numerous aspects of the invention both independently and as an overall system and both in a flow cytometry context and  
25 otherwise.

Further, each of the various elements of the invention and claims may also be achieved in a variety of manners. Additionally, when used or implied, an element is to be understood as encompassing individual as well as plural structures that may or may not  
30 be physically connected. This disclosure should be understood to encompass each such variation, be it a variation of an embodiment of any apparatus embodiment, a method or

process embodiment, or even merely a variation of any element of these. Particularly, it should be understood that as the disclosure relates to elements of the invention, the words for each element may be expressed by equivalent apparatus terms or method terms -- even if only the function or result is the same. Such equivalent, broader, or even more generic terms should be considered to be encompassed in the description of each element or action. Such terms can be substituted where desired to make explicit the implicitly broad coverage to which this invention is entitled. As but one example, it should be understood that all actions may be expressed as a means for taking that action or as an element which causes that action. Similarly, each physical element disclosed should be understood to encompass a disclosure of the action which that physical element facilitates. Regarding this last aspect, as but one example, the disclosure of an “amplifier” should be understood to encompass disclosure of the act of “amplifying” -- whether explicitly discussed or not -- and, conversely, were there effectively disclosure of the act of “amplifying”, such a disclosure should be understood to encompass disclosure of an “amplifier” and even a “means for amplifying” Such changes and alternative terms are to be understood to be explicitly included in the description.

Any patents, publications, or other references mentioned in this application for patent are hereby incorporated by reference. In addition, as to each term used it should be understood that unless its utilization in this application is inconsistent with such interpretation, common dictionary definitions should be understood as incorporated for each term and all definitions, alternative terms, and synonyms such as contained in the Random House Webster’s Unabridged Dictionary, second edition are hereby incorporated by reference. Finally, all references listed in the list of References To Be Incorporated By Reference In Accordance With The Provisional Patent Application or other information statement filed with the application are hereby appended and hereby incorporated by reference, however, as to each of the above, to the extent that such information or statements incorporated by reference might be considered inconsistent with the patenting of this/these invention(s) such statements are expressly not to be considered as made by the applicant(s).

Thus, the applicant(s) should be understood to have support to claim and make a statement of invention to at least: i) each of the signal measurement and signal analysis devices as herein disclosed and described, ii) the related methods disclosed and described, iii) similar, equivalent, and even implicit variations of each of these devices and methods, iv) those alternative designs which accomplish each of the functions shown as are disclosed and described, v) those alternative designs and methods which accomplish each of the functions shown as are implicit to accomplish that which is disclosed and described, vi) each feature, component, and step shown as separate and independent inventions, vii) the applications enhanced by the various systems or components disclosed, viii) the resulting products produced by such systems or components, ix) each system, method, and element shown or described as now applied to any specific field or devices mentioned, x) methods and apparatuses substantially as described hereinbefore and with reference to any of the accompanying examples, xi) the various combinations and permutations of each of the elements disclosed, xii) each potentially dependent claim or concept as a dependency on each and every one of the independent claims or concepts presented, xiii) processes performed with the aid of or on a computer as described throughout the above discussion, xiv) a programmable apparatus as described throughout the above discussion, xv) a computer readable memory encoded with data to direct a computer comprising means or elements which function as described throughout the above discussion, xvi) a computer configured as herein disclosed and described, xvii) individual or combined subroutines and programs as herein disclosed and described, xviii) the related methods disclosed and described, xix) similar, equivalent, and even implicit variations of each of these systems and methods, xx) those alternative designs which accomplish each of the functions shown as are disclosed and described, xxi) those alternative designs and methods which accomplish each of the functions shown as are implicit to accomplish that which is disclosed and described, xxii) each feature, component, and step shown as separate and independent inventions, and xxiii) the various combinations and permutations of each of the above.

With regard to claims whether now or later presented for examination, it should be understood that for practical reasons and so as to avoid great expansion of the

examination burden, the applicant may at any time present only initial claims or perhaps only initial claims with only initial dependencies. Support should be understood to exist to the degree required under new matter laws -- including but not limited to European Patent Convention Article 123(2) and United States Patent Law 35 USC 132 or other  
5 such laws -- to permit the addition of any of the various dependencies or other elements presented under one independent claim or concept as dependencies or elements under any other independent claim or concept. In drafting any claims at any time whether in this application or in any subsequent application, it should also be understood that the applicant has intended to capture as full and broad a scope of coverage as legally  
10 available. To the extent that insubstantial substitutes are made, to the extent that the applicant did not in fact draft any claim so as to literally encompass any particular embodiment, and to the extent otherwise applicable, the applicant should not be understood to have in any way intended to or actually relinquished such coverage as the applicant simply may not have been able to anticipate all eventualities; one skilled in the  
15 art, should not be reasonably expected to have drafted a claim that would have literally encompassed such alternative embodiments.

Further, if or when used, the use of the transitional phrase “comprising” is used to maintain the “open-end” claims herein, according to traditional claim interpretation.  
20 Thus, unless the context requires otherwise, it should be understood that the term “comprise” or variations such as “comprises” or “comprising”, are intended to imply the inclusion of a stated element or step or group of elements or steps but not the exclusion of any other element or step or group of elements or steps. Such terms should be interpreted in their most expansive form so as to afford the applicant the broadest coverage legally  
25 permissible.

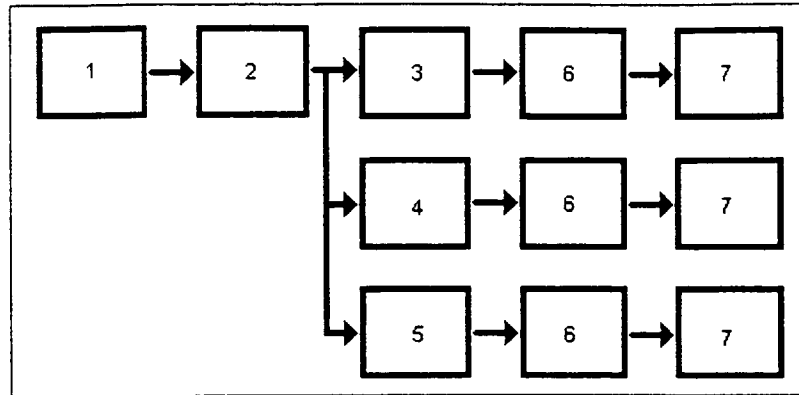
Finally, any claims set forth at any time are hereby incorporated by reference as part of this description of the invention, and the applicant expressly reserves the right to use all of or a portion of such incorporated content of such claims as additional  
30 description to support any of or all of the claims or any element or component thereof, and the applicant further expressly reserves the right to move any portion of or all of the

incorporated content of such claims or any element or component thereof from the description into the claims or vice-versa as necessary to define the matter for which protection is sought by this application or by any subsequent continuation, division, or continuation-in-part application thereof, or to obtain any benefit of, reduction in fees  
5 pursuant to, or to comply with the patent laws, rules, or regulations of any country or treaty, and such content incorporated by reference shall survive during the entire pendency of this application including any subsequent continuation, division, or continuation-in-part application thereof or any reissue or extension thereon.



## **ABSTRACT**

A flow cytometer capable of using electronics to analyze a large dynamic range while avoiding and/or correcting traditional limitations of acquisition electronics. The invention allows for measuring signal characteristics, which may include but are not  
5 limited to linear peak, integral, logarithmic peak, and pulse width. Other system parameters may also be generated by the invention to indicate timing or status information. Accurate and precise measurements may be performed by correcting for input errors if needed, and by transforming the input signal to produce a more easily measured form.



**Figure 1**

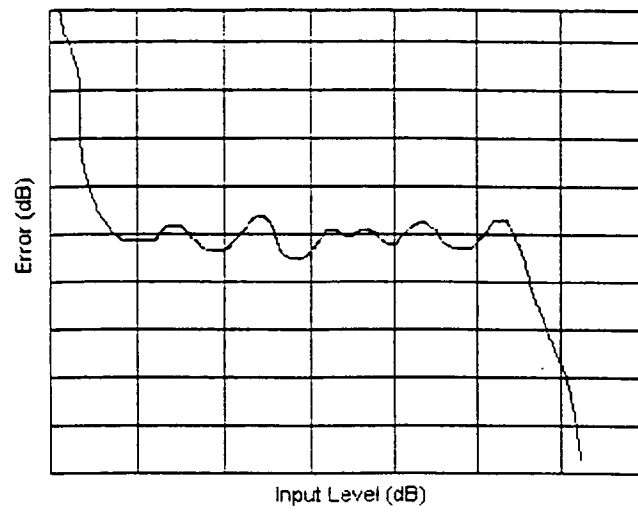


Figure 2

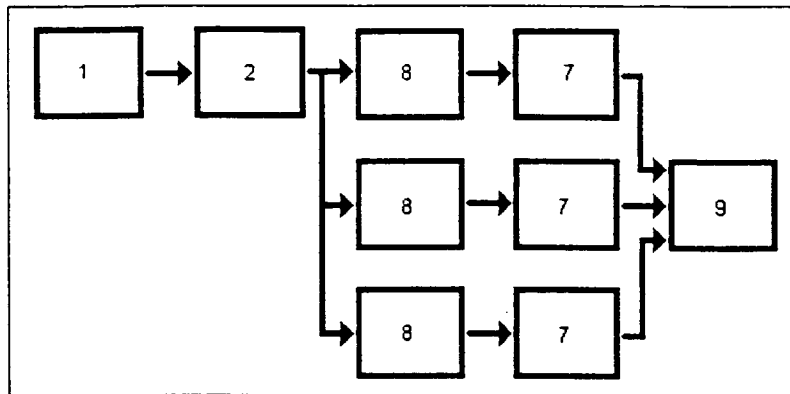


Figure 3

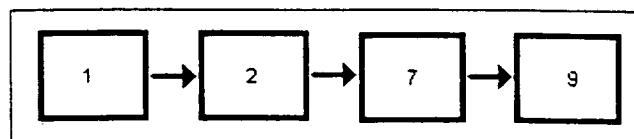
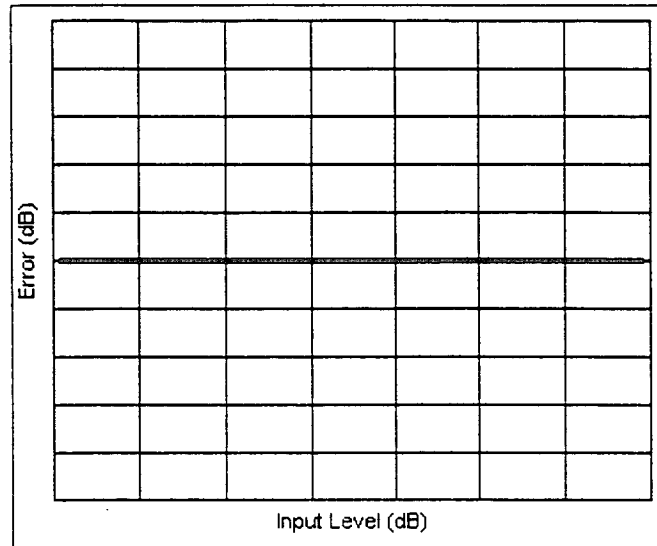
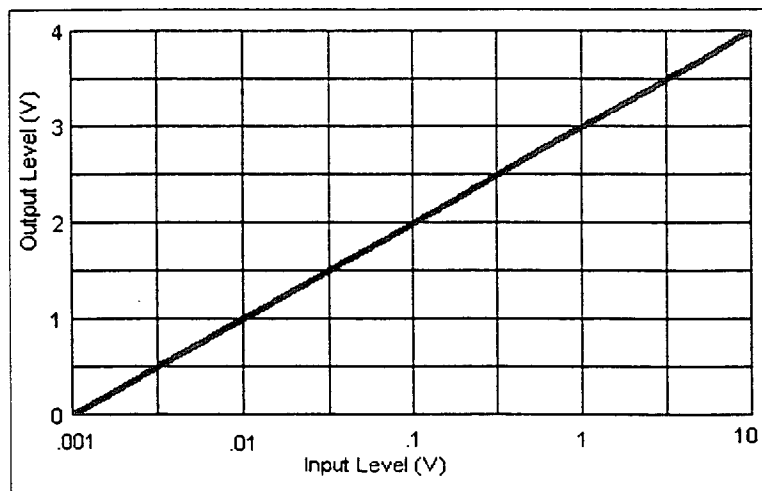


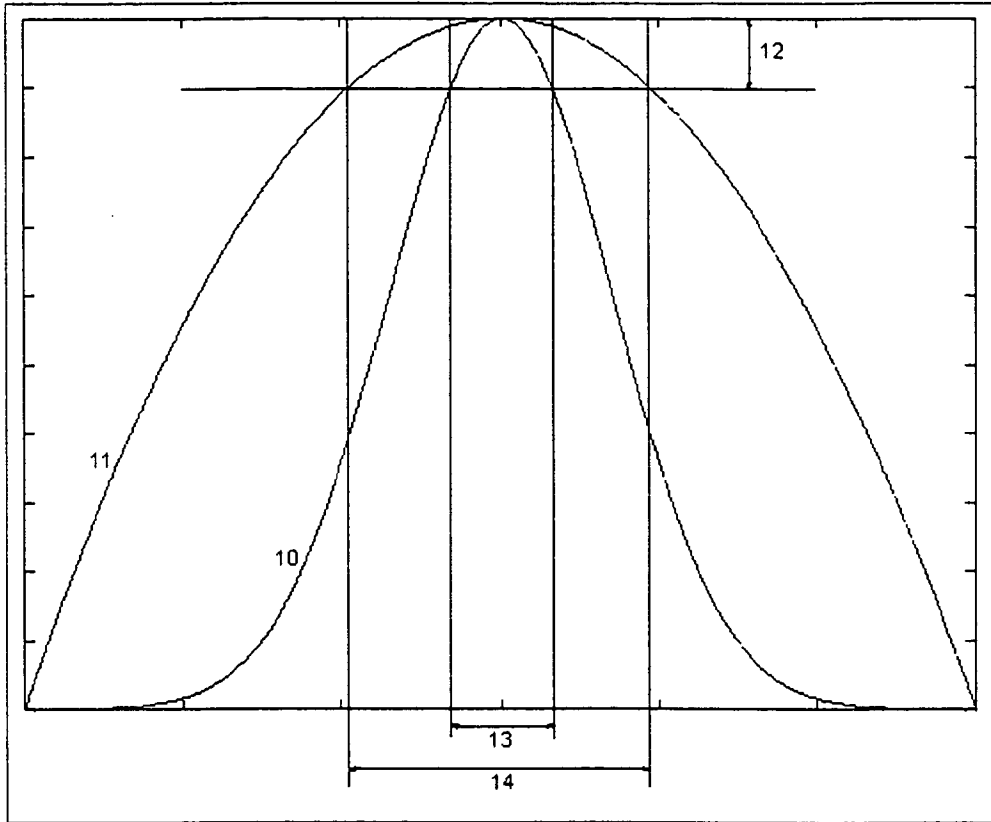
Figure 4



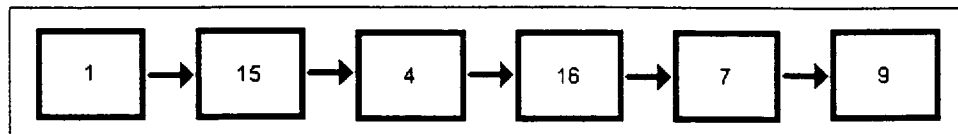
**Figure 5**



**Figure 6**



**Figure 7**



**Figure 8**

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UNITED STATES PATENT AND  
TRADEMARK OFFICE

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In Re the Provisional Application of: Theodore W. Jochum, Daniel N. Fox, Thomas L. Thrasher,  
George C. Malachowski

Serial Number:

Filed:

For: System for High Dynamic Range Analysis in Flow Cytometry

Assignee: DakoCytomation Denmark A/S

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**APPLICATION DATA SHEET**

**Application Information**

Application Type::	Provisional
Subject Matter::	Utility
CD-ROM or CD-R::	None
Title::	System for High Dynamic Range Analysis in Flow Cytometry
Attorney Docket::	DakoCytoFech
Request for Early Publication?::	No
Request for Nonpublication?::	No
Suggested Drawing Figure::	N/A
Total Drawing Sheets::	<u>4</u>
Small Entity::	No
Petition Included?::	No
Secrecy Order in Parent Appl.?::	No

**Applicant Information**

Applicant Authority Type::	Inventor
Primary Citizenship Country::	US
Status::	Full Capacity
Given Name::	Theodore W.
Family Name::	Jochum
City of Residence::	Fort Collins
State of Residence::	CO
Country of Residence::	US

Street of Mailing Address:: 720 Yarnell Court  
City of Mailing Address:: Fort Collins  
State or Province of Mailing Address:: CO  
Postal or Zip Code of Mailing Address:: 80525

**Applicant Information**

Applicant Authority Type:: Inventor  
Primary Citizenship Country:: US  
Status:: Full Capacity  
Given Name:: Daniel N.  
Family Name:: Fox  
City of Residence:: Fort Collins  
State of Residence:: CO  
Country of Residence:: US  
Street of Mailing Address:: 2726 Bradford Square  
City of Mailing Address:: Fort Collins  
State or Province of Mailing Address:: CO  
Postal or Zip Code of Mailing Address:: 80526

**Applicant Information**

Applicant Authority Type:: Inventor  
Primary Citizenship Country:: US  
Status:: Full Capacity  
Given Name:: Thomas L.  
Family Name:: Thrasher  
City of Residence:: Fort Collins  
State of Residence:: CO  
Country of Residence:: US  
Street of Mailing Address:: 2318 Kodiak Road  
City of Mailing Address:: Fort Collins  
State or Province of Mailing Address:: CO  
Postal or Zip Code of Mailing Address:: 80525

**Applicant Information**

Applicant Authority Type:: Inventor  
Primary Citizenship Country:: Australia  
Status:: Full Capacity  
Given Name:: George C.  
Family Name:: Malachowski  
City of Residence:: Fort Collins  
State of Residence:: CO  
Country of Residence:: US  
Street of Mailing Address:: 1112 Remington Street  
City of Mailing Address:: Fort Collins  
State or Province of Mailing Address:: CO  
Postal or Zip Code of Mailing Address:: 80524

**Correspondence Information**

EFS Customer Number:: 33549  
Name Line One:: Santangelo Law Offices, P.C.  
Address Line One:: 125 South Howes  
Address Line Two:: Third Floor  
City:: Fort Collins  
State or Province:: Colorado  
Country:: United States of America  
Postal or Zip Code:: 80521  
Telephone:: (970) 224-3100  
Fax:: (970) 224-3175  
Electronic Mail:: intentionally left blank

**Representative Information**

<b>Representative Designation::</b>	<b>Registration Number::</b>	<b>Representative Name::</b>
Primary	31,997	Luke Santangelo
Primary	48,665	Nicole A. Ressue
Associate	48,033	Alfred K. Wiedmann Jr.
Associate	55,417	Misha Gregory Macaw

**Continuity Information**

None

**Assignee Information**

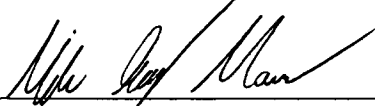
Assignee Name:: DakoCytomation Denmark A/S  
Street of Mailing Address:: Produktionsvej 42  
City of Mailing Address:: Glostrup  
State of Mailing Address  
Country of Mailing Address:: Denmark  
Zip Code of Mailing Address:: DK-2600  
Telephone:: 011- 45 44 8595 00



Dated this 3 day of March, 2004.

Respectfully Submitted,  
SANTANGELO Law Offices, P.C.

By::

  
Misha Gregory Macaw  
ATTORNEY FOR APPLICANT  
PTO No. 31,997  
125 South Howes, Third Floor  
Fort Collins, Colorado 80521  
(970) 224-3100